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## (54) Method and apparatus for navigating an automatic guided vehicle.

(57) A vehicle (3, 4), preferably an agricultural vehicle, such as a tractor, which vehicle comprises a transmitting or receiving system which is arranged to co-operate with a stationary receiving system or transmitting system, as the case may be. The vehicle (3, 4) also comprises controls (21, 22, 27, 28, 31, 32, 35, 36) which are remotely controllable in such a way by means of a computer (11) that the vehicle (3, 4) can be moved in a predetermined direction.

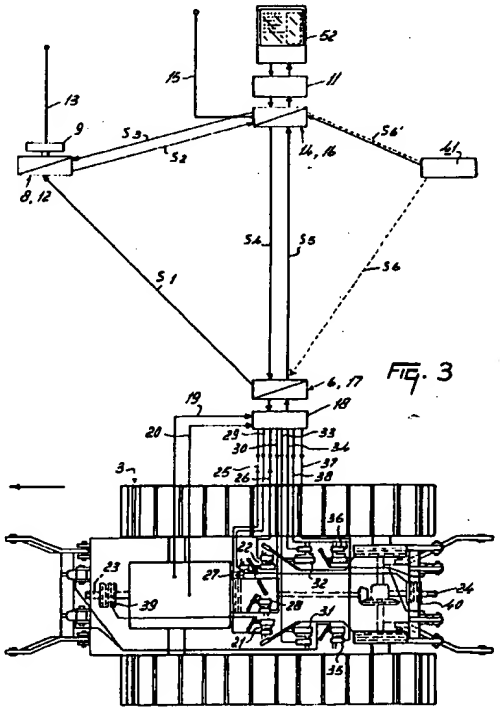

FIG. 3

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The present invention relates to a vehicle, preferably an agricultural vehicle, such as a tractor.

To make an automatic operation of the vehicle practicable in an advantageous way, according to the invention, this vehicle is provided with a transmitting or receiving system which is arranged to co-operate with a stationary receiving system or transmitting system as the case may be, while the vehicle at the same time comprises controls which are remotely controllable by means of a computer in such a way that the vehicle can be moved in a predetermined direction. The co-operating transmitting and receiving systems are arranged for radio communication.

In a first embodiment of the invention, the vehicle is provided with a transmitting system made up of a transmitter and a transmit antenna for determining the vehicle position with respect to a receiving system. The transmitter on the vehicle then is preferably provided with an omnidirectional antenna, so that the radiation pattern produced by the transmitter is the same in all directions. The transmitting system installed on the vehicle in this first embodiment according to the invention co-operates advantageously with a receiving system which is made up of a plurality of stationary receivers with receive antenna. Especially, the receiving system according to the invention is made up of at least three receivers with receive antenna, each of which is placed on a mast or tower on or near the corners of a plot of farming land. The receive antenna is directional and swivelling or rotatable. By means of the arrangement according to the first embodiment described above, the bearing angles of the vehicle with respect to a fixed reference line can be determined by the receivers of the receiving system.

In a particular embodiment according to the invention, the vehicle co-operates with a computer placed in a remote position, which computer is supplied with the bearing angles with respect to a fixed reference line measured by the receivers and which computer determines the successive position co-ordinates of the vehicle from the bearing angles received successively and derives control signals for the vehicle from said position co-ordinates. These angular values measured may be transmitted to the computer by radio or by wire. This enables the vehicle to be automatically controlled by the computer from a farm building. The fact is that the computer is capable of calculating the vehicle position co-ordinates from the bearing angles measured each time and of deriving, from these position co-ordinates, the path being followed by the vehicle in the field, after which this path can be compared against a predetermined path by means of the computer, so that deviations from the latter path can be determined, which deviations the computer can convert into control signals for course corrections of the vehicle in the field. Although the vehicle position can virtually always be determined from bearing angles measured by means of two receivers, it is preferable according to the invention to determine the vehicle position co-ordinates by statistically processing the position co-ordinates derived from the bearing angles each time measured by and obtained from two of the receivers.

Apart from the fact that the vehicle can be provided with a transmitting system made up of a transmitter and a transmit antenna for locating the vehicle with respect to a stationary receiving system made up of a plurality of receivers, it is also practicable to make use of a transmitting system which is made up of a plurality of stationary transmitters optionally operating on different frequencies and, provided on the vehicle, a receiving system made up of a receiver and a directional, rotatable receive antenna. In this second embodiment, again, bearing angles, viz. the bearing angles of the stationary transmitters being part of the transmitting system can be measured by means of the receiver on the vehicle, which angles, however, are taken with respect to a reference line defined in relation to the vehicle, for instance, the longitudinal axis of the vehicle. However, this implies that in the event that course corrections with regard to the vehicle are applied, the direction of this reference line is also changed. The bearing angles measured by means of the receiver on the vehicle should then again be transmitted by radio to a computer placed in a remote position.

In a third embodiment, instead of angle measurements such as implemented by means of goniometric determinations in the first two embodiments, measurements of differences in range between the receiver of a receiving system on the vehicle and the respective stationary transmitters of a transmitting system are made. According to the invention, the receiver on the vehicle is thereto provided with a phase detector to measure the phase difference between the signals originated by the transmitters and received by the receiver. The phase difference measured then corresponds to the relevant distance. In this embodiment, the transmitters preferably operate on different frequencies; in the receiver, however, these frequencies are transformed to one and the same frequency prior to the application of these signals to the phase detector. With this transformation the phase information and, consequently, the difference-in-range information is retained.

In a further preferred embodiment according to the invention, the vehicle is provided with a first transmitter/receiver which co-operates with a second transmitter/receiver placed in a remote position

and connected to a computer and with at least two stationary third transmitt rs/receivers, where signals for the determination of th vehicle position co-ordinates ar transmitted by the first transmitter, which signals can be received by said third receivers, and where the bearing angles derived from these signals are transmitted by the third transmitters, which bearing angles can be received by the second receiver. Furthermore, switching signals to put the third transmitter/receivers into and out of operation can be transmitted by the second transmitter, which switching signals can be received by the third receivers. Further, control and operating signals for the control and operation of the vehicle and the implements coupled thereto can be transmitted by the second transmitter, which control and operating signals can be received by the first receiver. Signals conveying information on the vehicle can also be transmitted by the first transmitter, which signals can be received by the second receiver.

Furthermore, the vehicle according to the invention can be provided with measuring and recording means to record vehicle parameters such as the speed of the engine, that of the power take-off shaft or shafts, the fuel supply available, etc. These vehicle parameters can be sent to the computer placed in a remote position through a transmitter on the vehicle and through a receiver connected to the computer. Moreover, the vehicle according to the invention can be provided with controls to engage and disengage the drive of the power take-off shaft, and also to operate the clutch and the gear-change, forward and reverse, of the vehicle, and/or to operate the front and/or rear lifting device, with the operating signals for these controls being applied from the computer, through a transmitter connected to the computer and a receiver connected to the controls.

According to the invention, the vehicle is preferably implemented as a caterpillar tractor which, on account of its stable movement and manoeuvrability, can be used advantageously in an agricultural machine combination operated automatically. So, the invention also relates to a vehicle, preferably an agricultural vehicle such as a tractor, characterized in that the vehicle is a caterpillar tractor provided with a transmitting and receiving system for automatic operation and control of the caterpillar tractor and the implements coupled thereto. The vehicle may then be provided with controls to operate the left-hand and right-hand track drives, with the operating signals for thes controls being applied from a comput r through a transmitt r conn ct d to the computer and a receiver conn cted to the controls. Besid s that the machin can be automatically controlled and operated in the above-stated manner, there can be provided means for manual control and operation of th machine from a position at a certain distanc . According to th invention, th vehicle is capabl of co-op rating with a remot control unit provided with a transmitter to control and operate the vehicle through a receiver on the vehicle and controls connected to this receiver. In a particular embodiment, the control and operating signals generated by means of the remote control unit can be sent to the vehicle through the intermediary of a computer provided with a transmitter/receiver and placed in a farm building.

The computer is provided with a program to have the vehicle move along a predetermined path. Accordingly, the invention also relates to a vehicle, preferably an agricultural vehicle such as a tractor, characterized in that the control of the vehicle comprises a computer provided with a program to cause the vehicle to move along a predetermined path. In this context, it is possible that the vehicle provided with at least one agricultural implement is moved back and forth across a field to be worked and is turned round at the extremities thereof. It is also possible to connect an agricultural implement of one and the same type to the front and rear sides of the vehicle, whilst the vehicle, without turning round but after a certain displacement in side-rearward or side-forward direction, is moved back and forth across a field to be worked, with one of the two agricultural implements, dependent on the direction of motion, being in the working condition.

The computer can also be provided with a program to work a field, to lift an implement coupled to the vehicle, to turn the vehicle etc. Here, the operation of parts of the vehicle, such as the lifting device, can be laid down in the program by an initial manual operation of these parts themselves, this operation being subsequently repeatable automatically by means of the program defined during this initial manual operation. Hence, the invention also relates to a vehicle, preferably an agricultural vehicle such as a tractor, characterized in that the operation of parts of the vehicle, such as a lifting device, is laid down in a program of a computer being part of the tractor control by means of an initial manual operation of these parts themselves, this operation being subsequently repeatable automatically by means of the program defined during this initial manual operation.

The vehicle, which can be constructed as an unmanned caterpillar tractor, is arranged for working a field automatically and continuously, especially by day and by night.

The invention will hereinafter further be explain d with referenc to the accompanying drawings, in which:

Figure 1 shows the farm buildings and plot of farming land, two vehicles provided with a transmitter which ar working there, and four stationary rec ivers;

Figure 2 shows a receiver with, installed on a mast, a directional receive antenna and a transmit antenna for communication with the farm buildings;

Figure 3 shows a top view of a caterpillar vehicle and a schematic representation of the co-operation of the vehicle and a computer placed in the farm buildings, a stationary receiver and a remote control unit;

Figure 4 shows a computer and, on top of it, a monitor which displays a field to be worked and a vehicle in action thereon;

Figure 5 shows a remote control unit, by means of which the vehicle can be controlled and operated;

Figures 6 and 7 show a caterpillar tractor to which, on the front side and on the rear side, a plough is coupled;

Figure 8 is a schematic representation of the way in which the tractor provided with implements as depicted in Figures 6 and 7 can be moved back and forth across the field;

Figures 9 and 10 show a caterpillar tractor to which a rotary harrow is coupled on the rear side;

Figures 11 and 12 show a caterpillar tractor to which a mowing machine is coupled on the rear side, and

Figure 13 is a schematic representation of how the machines depicted in Figures 9 to 12 can be moved across the field.

In Figure 1 there is shown a plot of ground with farm buildings 1, a farm house and barns. The plot of ground is divided into pieces of ground 2 to be worked individually, with two of these pieces of ground being worked by respective agricultural vehicles 3 and 4 in the form of a caterpillar tractor, to which one or several agricultural implements are coupled on the front and/or rear side. A transmitting system 5 comprising a transmitter 6 and a transmit antenna 7 is installed on each of the vehicles 3 and 4 (see Figures 6, 7 and 9 to 12). The antenna 7 is implemented as an omni-directional antenna, so that the radiation pattern generated by the transmitter is the same in all directions. The transmitting system 5 provided on each of the vehicles 3 and 4 co-operates with a receiving system which is made up of a plurality of stationary receivers 8, each provided with a rotatable, directional antenna 9. In Figur 1 each of thes r ceivers 8 provided with receive antenna 9 is plac d on a mast 10 in th vicinity of th corners of the farm ground, namely in positions marked by the letters A, B, C and D. Although in the depicted embodiment th transmitting system provided on the vehicle 3, 4 co-operates with a receiving system made up of receivers with receive antenna placed in positions A, B, C and D, it is possibl to replac the receivers with receive antenna placed in positions B and C with the receivers with receive antenna in positions E and F in the event that the field to be worked is of a different size. The angle between the direction of the vehicle 3, 4, with respect to a respective receiver 8 and a fixed reference line can be determined by means of the rotatable directional receive antenna 9. At least two of such bearing angles are necessary to determine the position of the vehicle 3, 4, since the distances between the respective receivers are known. However, as it may occur that the vehicle is on or near the line connecting two receivers, a third receiver is desirable for the determination of the vehicle position. A more accurate determination of the position is obtainable when even more receivers are placed on or near the plot of farming land. The angular values found by the receivers are passed on to a computer 11 preferably installed in a farm building 1 (see Figure 11). This transmission of angular values can be effected by radio or by wire communication. For radio communication, each mast 10 is provided with a transmitter 12 and an antenna 13, while, preferably in the same farm building where the computer 11 is placed, there is provided a receiver 14 with an antenna 15 (see Figure 3) for the purpose of receiving angular values transmitted by means of the transmitter 12 and passing on these values to the computer 11. The computer 11 derives the position of the vehicle 3, 4 from two angular values and the distance between the receivers by means of which the angular values have been determined. It is practicable to obtain a number of values for the vehicle position co-ordinates, from several combinations of, in each case, two angular values determined by means of receivers in neighbouring positions. Thus, the co-ordinates of the position of vehicle 3, 4 are obtainable from the locating data from the receivers placed in the positions A and B, from the receivers placed in the positions B and C, from the receivers placed in the positions C and D, and from the locating data from the receivers placed in the positions A and D. In this way it is possible to determine four pairs of position co-ordinates of the vehicle 3, 4, from which the definite position co-ordinates of the vehicle can be determined by statistical processing. From the vehicle position co-ordinates thus determined each time by the computer, the computer 11 is capable of d termining th path followed by th vehicle in the field, whereafter in the computer this path can be compar d against a pr determined path, so that deviations can be d termined, which deviations th computer 11 will covert into control signals for

course corr ctions to the vehicl 3, 4 in the field. The control signals fixed by the computer 11 can b transmitt d through a transmitter 16 provid d in the farm building and the ant nna 15, whilst on th vehicle 3, 4 there are provided a receiver 17 and controls to be defined into more detail to receive and process the automatic control signals fixed by the computer 11 as well as to control the vehicle accordingly.

Figure 2 depicts the mast 10, on which there are provided a receiver 8 and a transmitter 12 together with a rotatable directional receive antenna 9 and a transmit antenna 13. In the embodiment described there are four of such masts disposed on or near the corners of the plot of farming land.

In Figure 3 there is depicted the vehicle 3, a caterpillar tractor for instance, while in this figure it is also indicated schematically how this caterpillar tractor co-operates with control equipment disposed in a farm building and the various transmitters and receivers on or close to the corners of the plot of farming land. The caterpillar tractor is provided with a transmitter/receiver 6, 17, which co-operates with a transmitter/receiver 16, 14 disposed in a remote position and connected to the computer 11 and with the stationary transmitter/receivers 12, 8, of which only one is depicted in Figure 3, with signals S1 being transmitted by the transmitter 6 for the purpose of determining the position coordinates of the caterpillar tractor 3, which signals S1 can be received by the receiver 8, while the bearing angles S2 derived from these signals S1 are transmitted by the transmitter 12, which bearing angles S2 can be received by the receiver 14. Switching signals S3 to put the transmitter/receiver 12, 8 into and out of operation can be transmitted by the transmitter 16, which switching signals S3 can be received by the receiver 8. Additionally, control and operating signals S4 for the control and operation of the caterpillar tractor 3 and the implements to be coupled thereto can be transmitted by the transmitter 16, which control and operating signals S4 can be received by the receiver 17. Furthermore, signals S5 conveying information on the caterpillar tractor 3 can be transmitted by the transmitter 6, which signals can be received by the receiver 14. This information relates to vehicle parameters such as the speed of the engine and that of the power take-off shaft or shafts, the available fuel supply etc. For the determination of these vehicle parameters, measuring and recording means 18 to be further specified hereinafter are provided on the caterpillar tractor. Signals are passed on to the recording means 18 through lines 19 and 20 by means of measuring m ans not shown h r , which signals indicate the engine sp ed and the fuel supply availabl at the engine. Measuring means 21 and 22 for determining the speed of th power take-off shafts 23 and 24, respectively, apply signals to th recording means 18 through th lin s 25 and 26, respectively, which signals r present th speed of said power take-off shafts. The control and operation signals received by the receiver 17 are recorded by the recording means 18. On the caterpillar tractor there are provided controls 27 and 28 to operate the clutch and change gear, forward and reverse, of the caterpillar tractor 3, with the operating signals for these controls being applied thereto from the recording means 18 through the lines 29 and 30, respectively. Furthermore, on the caterpillar tractor 3 there are provided controls 31 and 32 to operate the left-hand and right-hand track drive, and, consequently, to steer the vehicle, with the operating signals for these controls 31 and 32 being applied thereto from the recording means 18 through the lines 33 and 34, respectively. In addition, on the caterpillar tractor 3 there are provided controls 35 and 36 to operate the respective lifting devices, one in front of the caterpillar tractor and one behind it, with the operating signals for these controls 35 and 36 being applied thereto from the recording means 18 through the lines 37 and 38, respectively. Finally, on the caterpillar tractor 3 there are provided controls 39 and 40 to engage and disengage the front power take-off shaft and the rear power take-off shaft, respectively, with the operating signals for these controls 39 and 40 being applied thereto from the recording means 18 through the said lines 25 and 26, respectively.

Besides that the caterpillar tractor 3 with the implements to be coupled thereto is capable of being automatically controlled and operated by means of the computer 11, the possibility of controlling and operating the machine by hand is provided. For this purpose there is provided a portable remote control unit 41. This remote control unit 41 can be placed in the room where the computer 11 is or equally well be taken along by the user to the field to be worked. The control and operating signals for the caterpillar tractor can be transmitted by radio from the remote control unit 41 either directly to the receiver 17 on the caterpillar tractor 3 or through the receiver 14 connected to the computer 11 and transmitter 16 to the receiver 17 provided on the caterpillar tractor 3. In Figure 3 the two possibilities are indicated by the signals S6 and S6'. Figure 5 illustrates a remote control unit 41 with a transmit antenna 42, a transmitter (not shown) with control electronics provided in the device, toggle-type controls 43 through 49 and control handles 50 and 51. Th controls 43, 44 and 46 serv to start and stop the ngine, th tractor's r ar power tak -off shaft and th front power tak -off shaft, r spectiv ly. Th controls 45 and 47 serv to put the respectiv lifting device on the rear side

and on the front side of th tractor into an upward position or a downward position. Th controls 48 and 49 ar to engage the clutch and to put the change gear into forward or reverse speed. Dep ndent on the controls which have been operated, the respective control and operating actions can be performed on the tractor by means of the control handles 50 and 51.

The way in which the tractor is controlled and operated, either fully automatically by means of the computer 11 or by means of the remote control unit 41, can be made visible by means of a monitor 52 connected to the computer 11. The computer 11 with the monitor 52 connected thereto is shown in Figure 4, where the monitor screen displays a field to be worked, including a vehicle in action, while also miscellaneous data concerning the tractor and its functioning are indicated on the screen. So, the tractor with the implements to be coupled thereto can be controlled and operated by means of the remote control unit 41, either from the field being worked itself on account of the user's visual observation of the tractor and the activities performed thereby or from the computer room on account of observation of the field with the tractor working thereon as displayed on the monitor 52.

There are various ways to accomplish the eventual programming of the computer 11. By a first method, for every specific process to be undergone by the soil or vegetation, the user carefully drives once through the respective plots. In doing so, the tractor is controlled by means of the remote control unit 41. The path then being covered is recorded by means of the position finding equipment and stored in the memory of the computer 11. The operation of the implements, such as for lifting and lowering the implements and putting the power take-off shaft into and out of operation, is put on record by the computer 11 through the transmitter 6 on the tractor and the receiver 16 connected to the computer 11. Once the tractor movement on the field to be worked and the operation of the implements have been fixed, the programming is completed, and the respective processes are frequently repeatable by causing the computer 11 to contact the tractor by radio communication. The eventual programming can also be effected by means of an exact specification of the field, for instance through cadastral data, with the software supplier then furnishing the complete programs for the different processes. The particular data on the field to be worked and on the tractor with implements to be utilised can be entered into the program by th user himself, if requir d.

Ther ar two ways to bring the tractor to the field. When the field is only accessibl through a public road, the vehicle has either to be manned and driven or to be transported on a trail r to this field. If it is not necessary to make use of a public road, the path from th farm building to the field can also b included in th program.

When the tractor is controll d from the computer 11, it remains necessary to conduct position finding all the time, providing a feedback to check whether the pre-programmed path is actually being followed, permitting a correction to be made as may be necessary. The position finding equipment is put into operation as soon as the non-recurrent tractor movement or the tractor movement under computer control starts and it is switched off as soon as the vehicle engine stops running; the switching signals S3 mentioned before are utilised for this purpose. When the position-finding results diverge excessively, the vehicle comes automatically to a standstill, since it is then assumed that a system failure has occurred. This also happens in the event that a receiver 8 needed for position finding breaks down.

Figures 6 and 7 depict a caterpillar tractor, to which agricultural implements of identical type are coupled on the front side and on the rear side, i.e. a plough 53 and plough 54, respectively. This arrangement enables the vehicle, without being turned round, but after a certain displacement in a side-rearward or side-forward direction (see Figure 8), to be moved back and forth across a field to be worked. Dependent on the direction of motion, one of the two agricultural implements will be in the operating condition. In the event that the caterpillar tractor depicted in Figures 6 and 7 is moved forward, the plough 54 coupled to the tractor on the rear side slides through the soil, whereas the lifting device keeps the plough coupled to the tractor on the front side in a raised position. When the caterpillar tractor is moved backward, the plough 53 is fed into the soil, whereas the plough 54 is lifted to above the soil surface level. Figures 9 and 10 depict a caterpillar tractor, to which a rotary harrow is coupled on the rear side, while in Figures 11 and 12 a seed drill is coupled to the caterpillar tractor on the rear side. In such situations, the vehicle is moved back and forth across a field to be worked, the vehicle being turned round at the extremities, as is indicated in Figure 13.

## Claims

1. A vehicle (3, 4), preferably an agricultural vehicle, such as a tractor, characterized in that the vehicle (3, 4) comprises a transmitting (5) or receiving system which is arranged to cooperat with a stationary r ceiving system or transmitting system, as the case may be, while the vehicle (3, 4) at the same time compris s controls (21, 22, 27, 28, 31, 32, 35, 36) which are remotely controllable by means of a com-

puter (11) in such a way that the vehicle (3, 4) can be moved in a predetermined direction.

2. A v hicle (3, 4) as claimed in claim 1, characterized in that the co-operating transmitting and receiving systems are arranged for radio communication.

3. A vehicle (3, 4) as claimed in claim 1 or 2, characterized in that the vehicle (3, 4) is provided with a transmitting system (5) made up of a transmitter (6) and a transmit antenna (7) for determining the vehicle position with respect to a receiving system.

4. A vehicle (3, 4) as claimed in claim 3, characterized in that the transmit antenna (7) is an omnidirectional one.

5. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that the transmitting system (5) provided on the vehicle (3, 4) co-operates with a receiving system made up of a plurality of stationary receivers (8) with receive antenna (9).

6. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that the transmitting system (5) provided on the vehicle (3, 4) co-operates with a receiving system made up of at least three receivers (8) with receive antenna (9), each of which is placed on a mast (10) or tower on or near the corners (A, B, C, D) of a plot of farming land (2).

7. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that the transmitting system (5) provided on the vehicle (3, 4) co-operates with a receiving system made up of a plurality of receivers (8), each of which is provided with a swivelling or rotary directional receive antenna (9).

8. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that the vehicle (3, 4) co-operates with a computer (11) placed in a remote position, which computer (11) is supplied with the bearing angles with respect to a fixed reference line measured by the receivers (8) of a receiving system and in which computer (11) the successive position co-ordinates of the vehicle (3, 4) are determined from the bearing angles obtained successively, with control signals for th vehicle (3, 4) b ing deriv d from said position co-ordinates in th comput r (11).

9. A vehicl (3, 4) as claimed in claim 8, characterized in that its position co-ordinates are determined by processing statistically th position co-ordinat s d rived from the b aring angles determined each time from two of the receivers.

10. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that the vehicle (3, 4) co-operates with a computer (11) with monitor (52) placed in a farm building.

11. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that its position co-ordinates are determined by the computer (11) from the bearing angles fixed by the receivers (8) and transmitted to the computer (11) by radio.

12. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that the vehicle (3, 4) is provided with a first transmitter/receiver (6, 17) which co-operates with a second transmitter/receiver (16, 14) placed in a remote position and connected to a computer (11) and with at least two stationary third transmitter/receivers (12, 18), where signals (S1) for the determination of the vehicle (3, 4) position co-ordinates are transmitted by the first transmitter (6), which signals (S1) can be received by said third receivers (8), and where the bearing angles (S2) derived from these signals (S1) are transmitted by the third transmitters (12), which bearing angles (S2) can be received by the second receiver (14).

13. A vehicle (3, 4), preferably an agricultural vehicle, such as a tractor, characterized in that the vehicle (3, 4) is provided with a first transmitter/receiver (6, 17) which co-operates with a second transmitter/receiver (16, 14) placed in a remote position and connected to a computer (11) and with at least two stationary third transmitter/receivers (12, 8), where signals (S1) for the determination of the vehicle (3, 4) position co-ordinates are transmitted by the first transmitter (6), which signals (S1) can be received by said third receivers (8), and where the bearing angles (S2) derived from these signals (S1) are transmitted by the third transmitters (12), which bearing angles (S2) can be received by the second receiver (14).

14. A vehicle (3, 4) as claimed in claim 12 or 13, characterized in that switching signals (S3) to put the third transmitter/r ceivers (12, 8) into and out of operation ar transmitted by th second transmitter (16), which switching sig-

nals (S3) can be received by th third receivers (8).

15. A vehicle (3, 4) as claimed in claim 12, 13 or 14, characterized in that control and operating signals (S4) for the control and operation of the vehicle (3, 4) and the implements coupled thereto can be transmitted by the second transmitter (16), which control and operating signals can be received by the first receiver (17).

16. A vehicle (3, 4) as claimed in any one of claims 12 to 15, characterized in that signals (S5) conveying information on the vehicle (3, 4) are transmitted by the first transmitter (6), which signals can be received by the second receiver (14).

17. A vehicle (3, 4) as claimed in claim 1 or 2, characterized in that the vehicle (3, 4) is provided with a receiving system made up of a receiver (17) and a receive antenna for determining the vehicle position with respect to a transmitting system.

18. A vehicle (3, 4) as claimed in claim 1, 2 or 17, characterized in that the receiving system provided on the vehicle (3, 4) co-operates with a transmitting system made up of a plurality of stationary transmitters (12) with transmit antenna (13).

19. A vehicle (3, 4) as claimed in claim 1, 2, 17 or 18, characterized in that the receiving system provided on the vehicle (3, 4) co-operates with a transmitting system made up of at least three stationary transmitters (12) with transmit antenna (13), with each of them being placed on or near the corners (A, B, C, D) of a plot of farm land (2).

20. A vehicle (3, 4) as claimed in any one of claims 17 to 19, characterized in that the receive antenna on the vehicle (3, 4) is directional and rotatable.

21. A vehicle (3, 4) as claimed in any one of claims 1, 2, 17 to 20, characterized in that the vehicle (3, 4) co-operates with a computer (11) placed in a remote position, which computer (11) is supplied with the bearing angles, determined by the receiver of a receiving system on th vehicl (3, 4) with respect to a referenc lin defined in relation to the vehicle (3, 4), of stationary transmitters (12) being part of the transmitting system, and in which computer (11) th successive position co-ordinates of the vehicle (3, 4) ar determin d from the bearing angl s obtained successively, with control signals for the vehicl being d riv d from these position co-ordinates in the computer.

22. A vehicle (3, 4) as claimed in claim 17, 18 or 19, characterized in that the receiver (17) on the vehicle (3, 4) is provided with a phase detector to measure the phase difference between the signals originated by the transmitters (12) and received by the receiver (17).

23. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that the vehicle (3, 4) comprises measuring and recording means (18) to record vehicle (3, 4) parameters such as the speed of the engine, that of the power take-off shaft or shafts (23, 24), the fuel supply available, etc.

24. A vehicle (3, 4) as claimed in claim 23, characterized in that the vehicle (3, 4) co-operates with a computer (11) placed in a remote position, which computer (11) is supplied with the vehicle parameters through a transmitter (6) on the vehicle (3, 4) and through a receiver (14) connected with the computer (11).

25. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that on the vehicle (3, 4) there are provided controls (21, 22) to engage and disengage the drive of the power take-off shaft (22, 23), where the operating signals for these controls (21, 22) are supplied thereto from the computer (11), through a transmitter (16) connected to the computer (11) and a receiver (17) connected to the controls (21, 22).

26. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that on the vehicle (3, 4) there are provided controls (27, 28) to operate the clutch and the gear-change, forward and reverse, of the vehicle (3, 4), where the operating signals for these controls are supplied thereto from the computer (11), through a transmitter (16) connected to the computer (11) and a receiver (17) connected to the controls (27, 28).

27. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that on the vehicle (3, 4) there are provided controls (35, 36) to op rate th front and/or r ar lifting d - vice, where the op rating signals for th se controls (35, 36) ar suppli d from th computer (11), through a transmitter (16) conn ct- ed to the computer (11) and a receiv r (17)

connected to th controls (35, 36).

28. A vehicle (3, 4) as claimed in any one of the prec ding claims, characterized in that the vehicle (3, 4) is a caterpillar tractor provided with a transmitting and receiving system for automatic operation and control of the caterpillar tractor and the implements coupled thereto.

29. A vehicle (3, 4), preferably an agricultural vehicle, such as a tractor, characterized in that the vehicle (3, 4) is a caterpillar tractor provided with a transmitting and receiving system for automatic operation and control of the caterpillar tractor and the implements coupled thereto.

30. A vehicle (3, 4) as claimed in claim 28 or 29, characterized in that on the vehicle (3, 4) there are provided controls (31, 32) to operate the left-hand and right-hand track drive, where the operating signals for these controls (31, 32) are supplied thereto from the computer (11), through a transmitter (16) connected to the computer and a receiver (17) connected to the controls (31, 32).

31. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that the vehicle (3, 4) co-operates with a remote control unit (41) provided with a transmitter to control and operate the vehicle (3, 4) through a receiver (17) on the vehicle (3, 4) and controls connected to this receiver (17).

32. A vehicle (3, 4) as claimed in claim 31, characterized in that the control and operating signals generated by means of the remote control unit (41) are sent to the vehicle through the intermediary of a computer (11) provided with a transmitter/receiver (16, 14) and placed in a farm building.

33. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that the control of the vehicle (3, 4) comprises a computer provided with a program to cause the vehicle to move along a predetermined path.

34. A vehicle (3, 4), preferably an agricultural vehicle, such as a tractor, characterized in that the control of the vehicle (3, 4) comprises a computer (11) provided with a program to cause the vehicle to move along a predetermined path.

35. A v hicle (3, 4) as claim d in claim 34, characterized in that an agricultural implem nt (53, 54) of one and th same type is coupled to the front and rear sid s of th vehicle (3, 4), whilst the v hicl (3, 4) , without turning round but after a c rtain displacement in side-r arward or side-forward direction, is moved back and forth across a field (2) to be worked, with one of the two agricultural implements (53, 54), dependent on the direction of motion, being in the working condition.

36. A vehicle (3, 4) as claimed in claim 34, characterized in that at least one agricultural implement (53, 54) is coupled to the vehicle (3, 4), while the vehicle (3, 4) is moved back and forth across a field (2) to be worked and is turned round at the extremities thereof.

37. A vehicle (3, 4) as claimed in any one of claims 34 to 36, characterized in that the computer (11) is provided with a program to work a field (2), to lift an implement (53, 54) coupled to the vehicle, to turn the vehicle (3, 4) round etc.

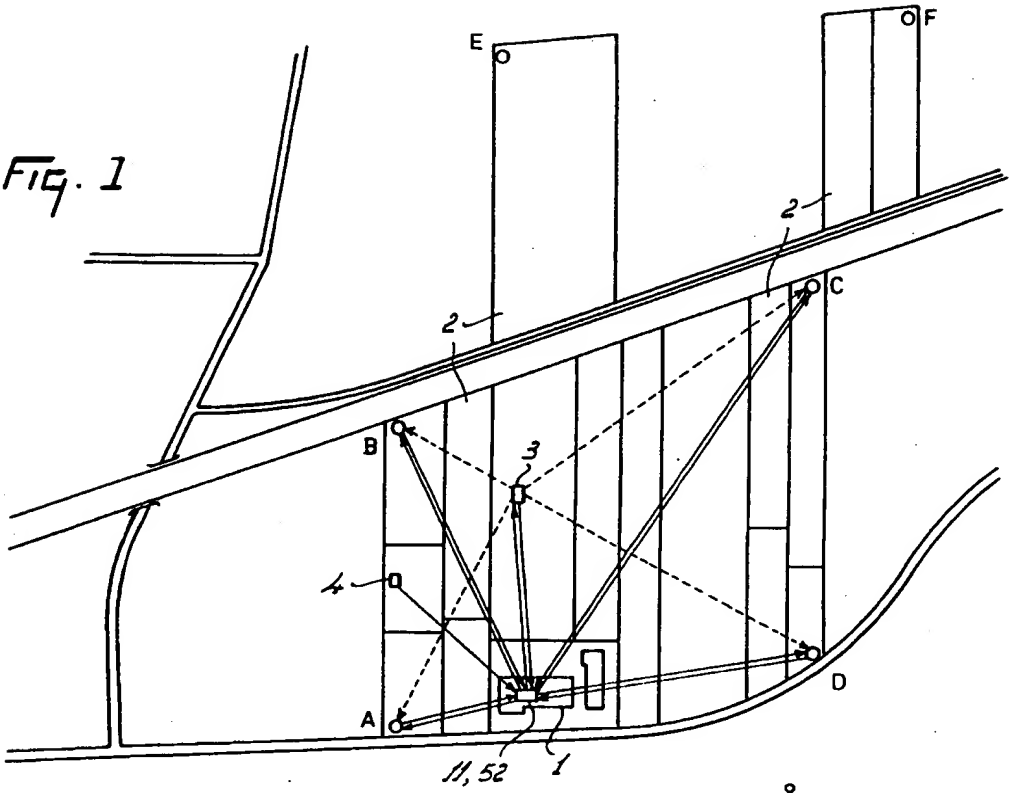
38. A vehicle (3, 4) as claimed in any one of claims 34 to 37, characterized in that the operation of parts of the vehicle (3, 4), such as a lifting device, is laid down in the program by means of an initial manual operation of these parts themselves, this operation being subsequently repeatable automatically by means of the program defined during this initial manual operation.

39. A vehicle (3, 4), preferably an agricultural vehicle, such as a tractor, characterized in that the operation of parts of the vehicle (3, 4), such as a lifting device, is laid down in a program of a computer (11) being part of the tractor control by means of an initial manual operation of these parts themselves, this operation being subsequently repeatable automatically by means of the program defined during this initial manual operation.

40. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that it is an unmanned caterpillar tractor.

41. A vehicle (3, 4) as claimed in any one of the preceding claims, characterized in that it is arranged for working automatically and continuously, preferably by day and by night.

FIG. 1



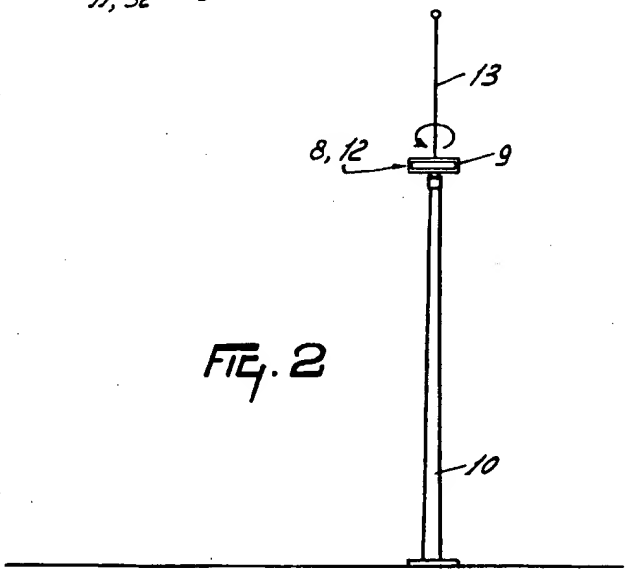
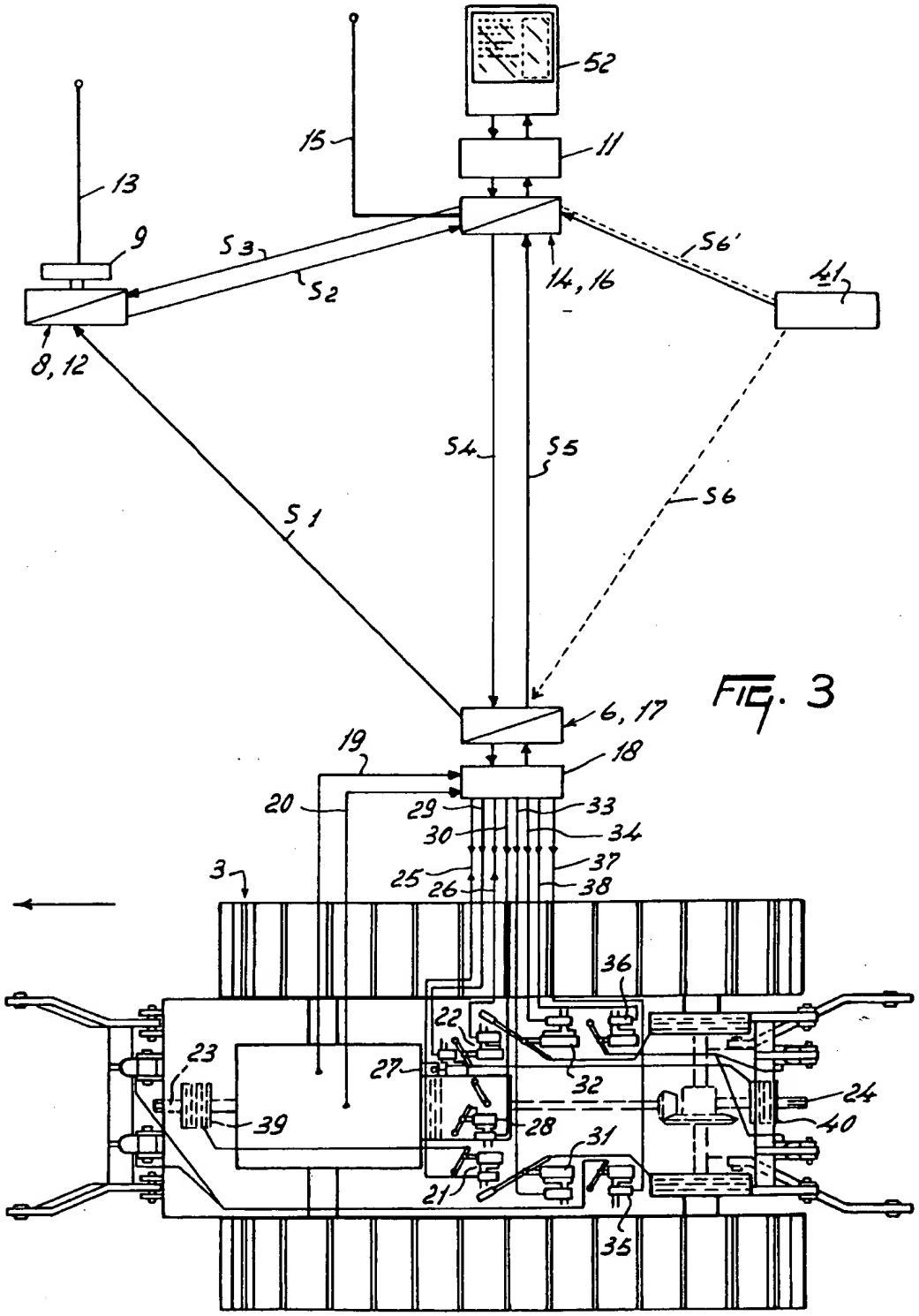




FIG. 2


52
11
15
13
9
S3
S2
S6'
14, 16
41
8, 12
S4
S5
S6
S1
6, 17
19
18
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29
33
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FIG. 3

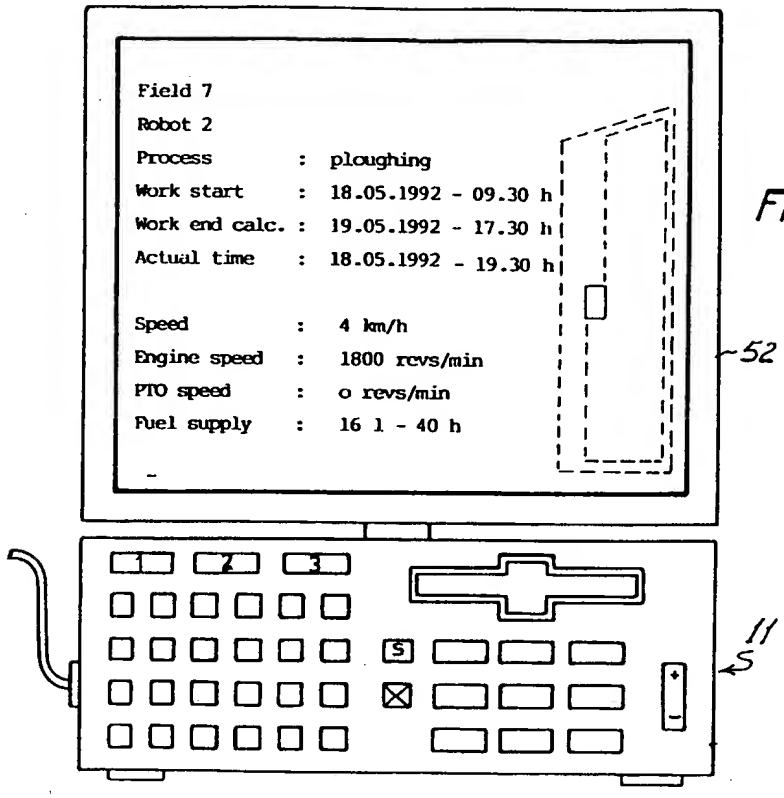

Field 7
Robot 2
Process : ploughing
Work start : 18.05.1992 - 09.30 h
Work end calc. : 19.05.1992 - 17.30 h
Actual time : 18.05.1992 - 19.30 h
Speed : 4 km/h
Engine speed : 1800 revs/min
PTO speed : o revs/min
Fuel supply : 16 l - 40 h
52
11

FIG. 4

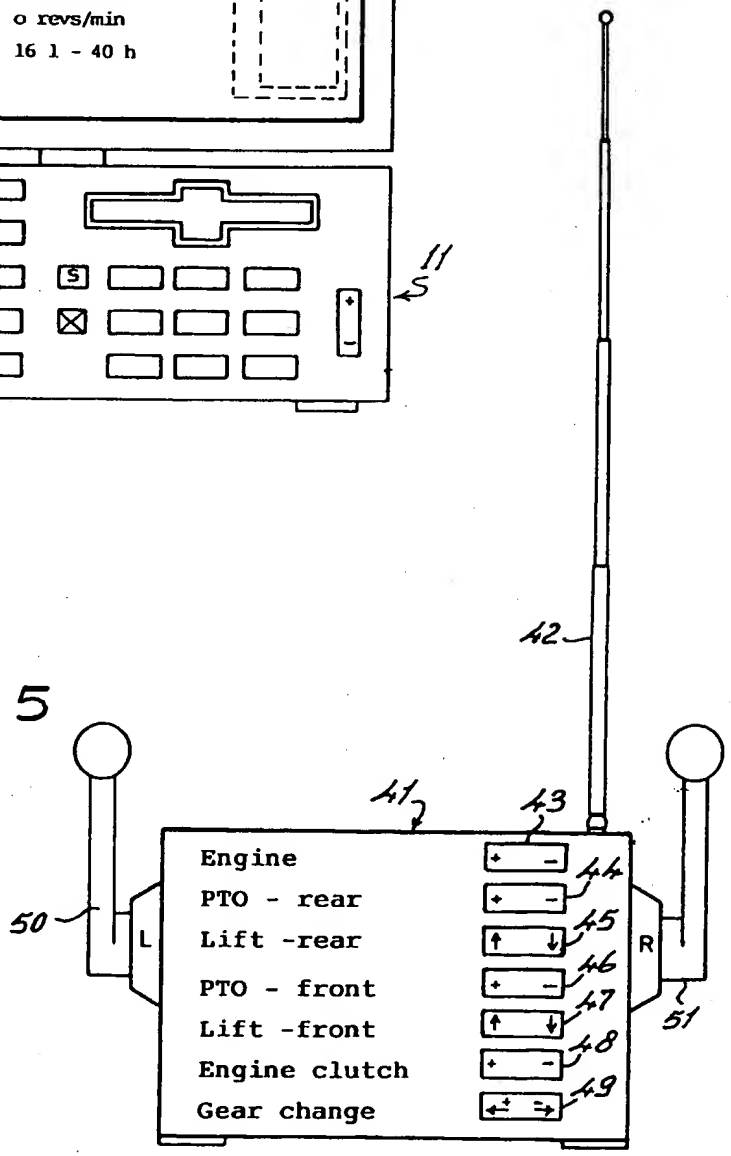

42
41
43
Engine
PTO - rear
Lift -rear
PTO - front
Lift -front
Engine clutch
Gear change
44
45
46
47
48
49
50
51
L
R

FIG. 5

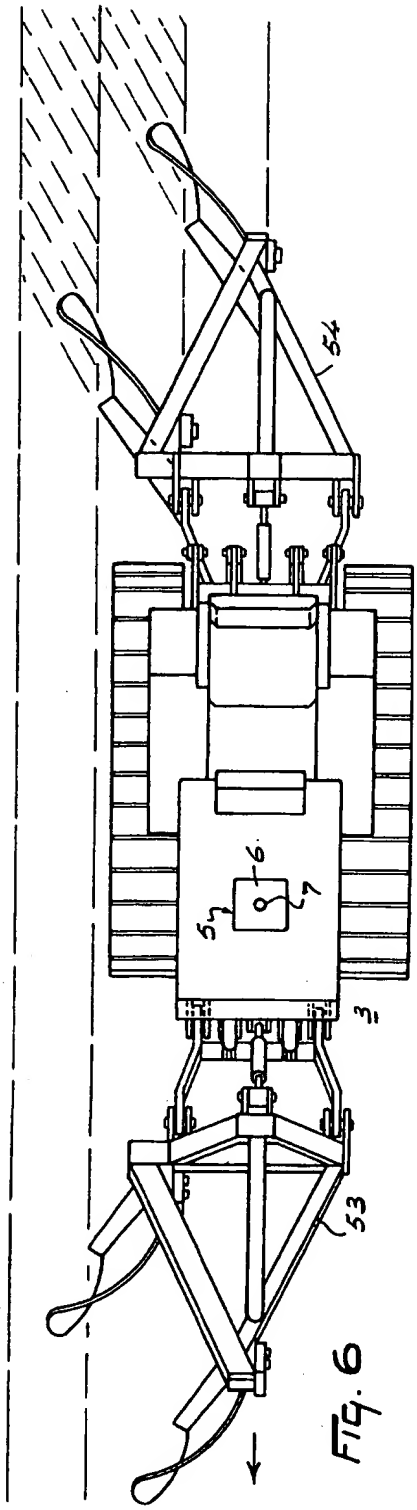



FIG. 6

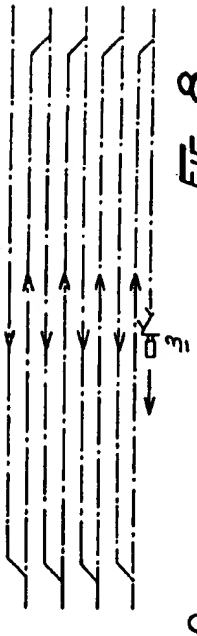



FIG. 8




FIG. 7

FIG. 9

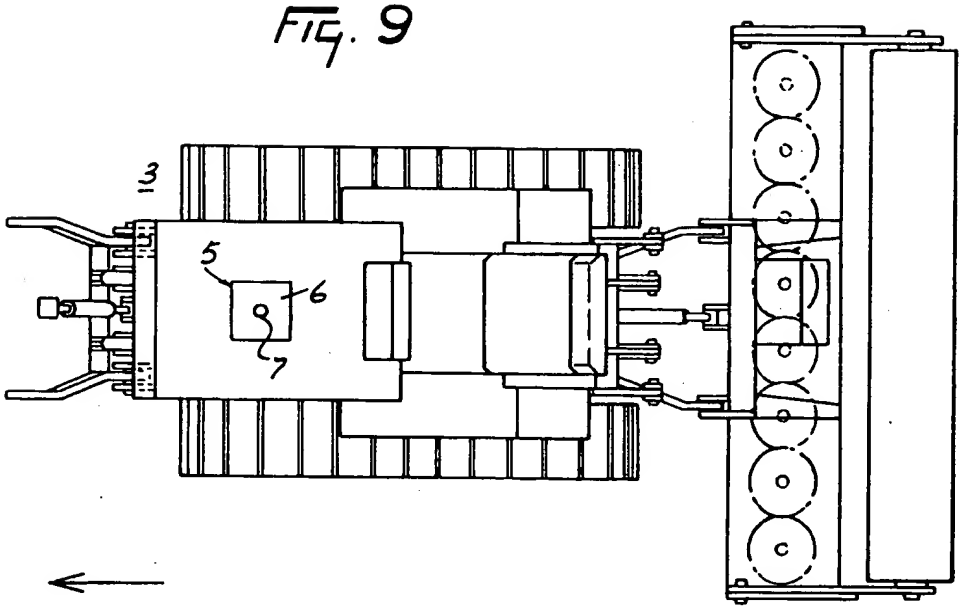



FIG. 10

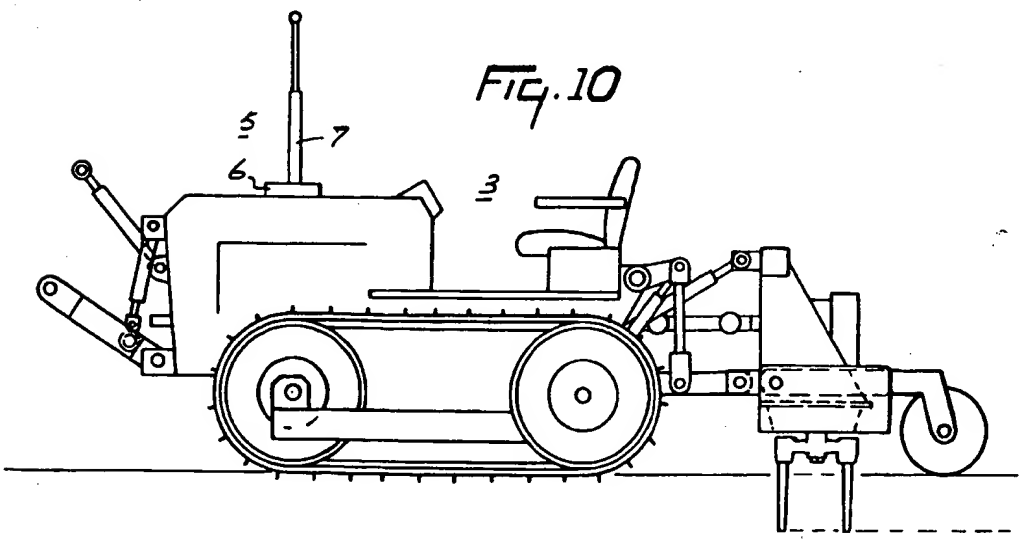
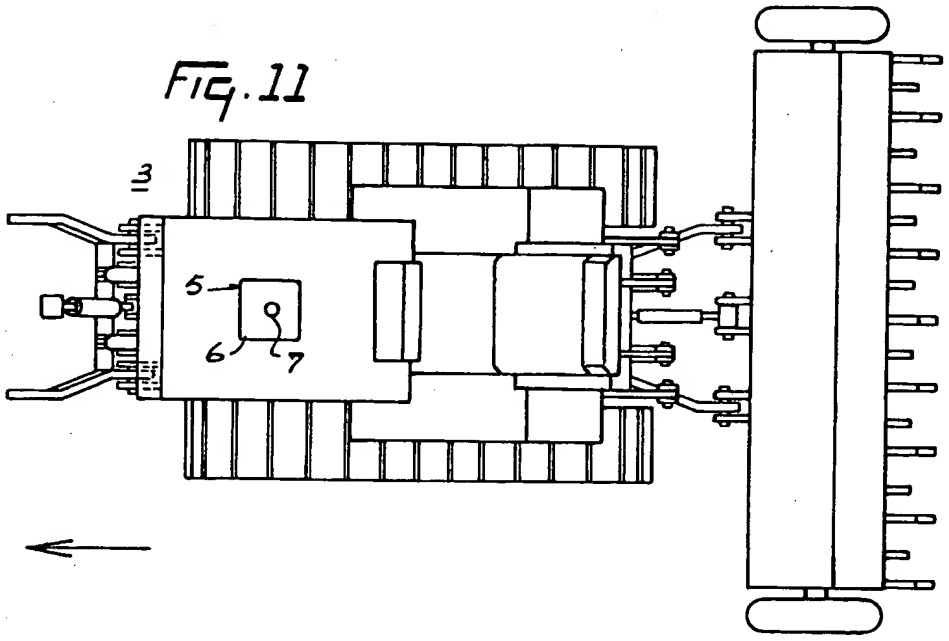


FIG. 11



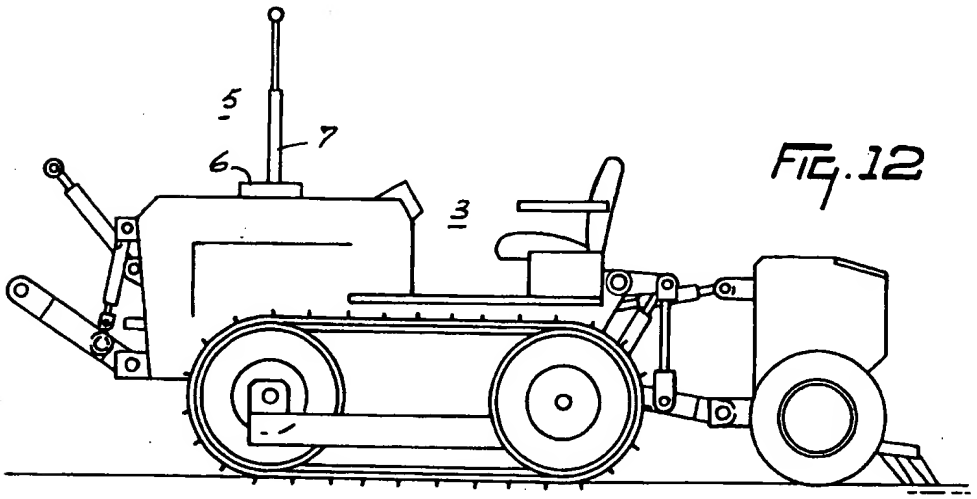
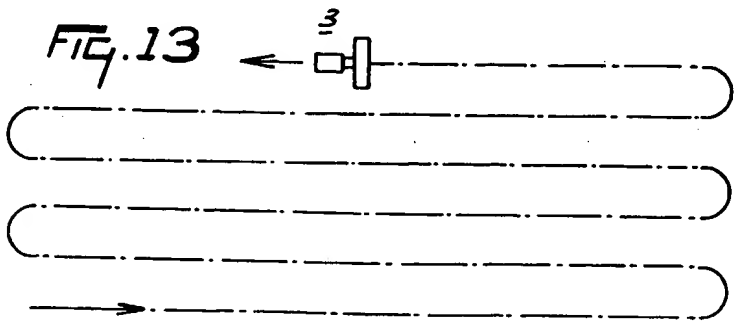




FIG. 12

FIG. 13



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# EUROPEAN SEARCH REPORT

Application Number

EP 93 20 1974



## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
|---|---|---|---|
| X | EP-A-0 423 332 (KABUSHIKI KAISHA KOMATSU SEISAKUSHO)<br>* abstract; page 2, line 48 - page 3, line 25; page 3, line 45 - page 4, line 58; page 5, line 57 - page 6, line 48; page 7, line 37 - page 9, line 41; figures 1 - 7 *<br>--- | 1,2, 17-19, 21-26, 31-34 | G05D1/02<br>G01S5/02<br>G01S5/08<br>A01B69/00 |
| X | US-A-4 986 384 (OKAMOTO ET AL.)<br>* abstract; column 1, line 49 - column 2, line 17; column 2, line 44 - column 3, line 46; column 5, line 10 - column 7, line 45; figures 1, 2, 7 ,8 *<br>--- | 1,2, 8-13, 15-19, 21, 23-27, 31-34 | |
| A | DE-A-3 526 564 (FRIED. KRUPP GMBH)<br>* column 3, line 35 - column 6, line 67; claims 1 - 7 ; figures 1 - 3 *<br>--- | 1,2,8, 11,17-19 | TECHNICAL FIELDS SEARCHED (Int. Cl.5)<br>G05D<br>G01S<br>A01B<br>E02F |
| A | US-A-4 939 522 (NEWSTEAD ET AL.)<br>* abstract; column 2, line 35 - column 7, line 3; figures 1 - 3 *<br>--- | 1,2,8, 11, 17-19, 24-26,31 | |
| A | FR-A-2 656 429 (COMMISSARIAT A L'ENERGIE ATOMIQUE)<br>* page 1, lines 1 - 28; page 3, line 14 - page 4, line 8; figures 1, 2 *<br>--- | 1-6 | |
| | -/-- | | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 22 OCTOBER 1993 | BEITNER M. |

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|---|---|---|---|
| A | FR-A-2 520 185 (PRECICULTURE)<br><br>* page 1, lines 3 - 13; page 2, lines 13 - 20; page 3, lines 18 - 37; page 4, lines 20 - 30; page 5, line 32 - page 6, line 24; page 7, line 21 - page 10, line 9; page 15, line 28 - page 16, line 7; claims 1 - 5; figures 1 - 3 * | 1-3, 33-39 | |
| A | DE-C-1 113 253 (WEISHEIT)<br><br>* whole document * | 1-3,5,6, 20 | |
| | | | TECHNICAL FIELDS SEARCHED (Int. Cl.5) |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 22 OCTOBER 1993 | BEITNER M. |

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& : member of the same patent family, corresponding document

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